ORIGINAL
Claims 1-12

I CLAIM:

1. A Downhole Flow Control Apparatus, including various pre-fabricated elements, shipped to and installed, on-site from the surface, within the casing and well head of a substantially vertical Heavy Oil well, crossing a cold environment, and

said vertical well casing, from the surface, connects, in its lower part, downhole, below said cold environment, to the perforated, nearly horizontal, portion of a Liner-equipped Lateral well, via a non-perforated, cemented curved part of the Liner string of said Lateral well,

and wherein,

said Apparatus includes two main connecting Modular elements, installed by means of a Conventional rig:

respectively, the first element within said curved part of said Liner string, and the second element within a portion of said Casing, said casing portion being dedicated to said Lateral well, for providing Downhole flow connecting means:

- to connect both said Modular elements with a quasi-horizontal tubing string hung in said Lateral well's Liner and with the annular space surrounding said horizontal tubing string, in said Liner,
- to connect both said elements with a vertical "Super-insulated" tubing string, dedicated to conveying downwards a stream of wet Steam from said vertical well's well head to the most distant end of said horizontal tubing string,
- to connect both said elements with a vertical "Super-insulated"

tubing string, dedicated to transporting upwards the hot fluids, produced from said Lateral well, to said vertical well's well head,
- to connect both said elements with one or more vertical tubing strings, dedicated to transporting downwards a Cold stream of Oil-Lifting fluid, from the vertical well head via the casing annular space around said "Super-insulated" tubings, to said elements, and for providing Downhole flow interrupting means:
- to periodically interrupt, with surface-operated Valves, or with retrievable plugs, in said Apparatus, the respective flows of:

Steam from the surface into said horizontal tubing string, of Oil-Lifting fluid from the surface into said Apparatus, and of reservoir fluids produced from said Lateral well into said Apparatus.

2. A plurality of Downhole Flow Control Apparatus of Claim 1, in a Multi-lateral vertical cased Well, connected to each of the cemented Liner stubs of a plurality of side-way, quasi-horizontal, Lateral wells, drilled into a Heavy Oil reservoir, below a cold environment, and operated in Sequential Cyclic Steam Injection and Production,

wherein,

one or more of said Lateral wells injects wet Steam, from a Generator at the surface, via a dedicated and shared "Super-insulated" Steam tubular assembly, coaxially located within said vertical cased Well, into said Heavy Oil reservoir, or

wherein,

previously injected Steam in other Lateral wells soaks and rises into said reservoir, heating the Oil, in said reservoir,

wherein,

previously Steam soaked Lateral wells produce said heated Oil, from said reservoir and convey said Oil to the surface, by means of a continuous Oil-Lift flow system, located, in part, within the Apparatus of each previously soaked Lateral well,

wherein,

Cold dry Oil-lifting fluid at the surface, circulates downward into said casing and Liners and returns back to the surface, mixed with said heated Oil, and with Steam condensate, from all the producing Lateral wells, via their respective Apparatus' and via a dedicated, shared, "Super-insulated" vertical coaxial Production tubular assembly, with minimum heat losses to said Cold environment,

wherein,

each said Lateral well successively operates first in the Steam injection mode, second in the Steam soak and rise mode and third in the Oil Production mode, for repeated cycles, initiated from the surface, by means of remotely-controlled Valves, of wireline plugs, of Oil-lifting fluid valves, of float valves or other Artificial lift devices and of associated tubular pipes, included in each said Downhole Flow Control Apparatus pre-fabricated and assembled into modular elements, transported to the Well site and respectively installed in the cemented curved Liner of each said Lateral well, or in a dedicated portion of said cemented Well casing, by means of auxiliary tools, used in a Service rig.

3. The pre-fabricated Apparatus of Claim 2, installed in each Lateral well and in a dedicated portion of said vertical Well casing includes a First Modular element, and a Second Modular element,

wherein,

said First Modular element includes means :

- to connect to a conventional tubing, installed in the quasi-horizontal part of said Lateral well,
- to connect to the annular space around said conventional tubing, within said Lateral well,
- to deliver Steam into said annular space, from said Second Modular element, for the subsequent injection and soaking of said Steam into said Heavy Oil reservoir,
- to connect to said Second Modular element of said Apparatus, located above said First Modular element, primarily within said portion of the vertical Well casing dedicated to said Lateral well,
- to convey a heated Oil stream flowing from said reservoir into said conventional tubing and into said tubing's annular space, via the First Modular Assembly element, to said Second Modular Assembly element, by means of natural Steam-lift and Artificial Oil-lifting systems.

4. The Apparatus of Claim 3, wherein each said Lateral well includes a quasi-horizontal portion, equipped with a perforated Liner string, cemented or not, coupled to a larger diameter curved Liner string, cemented from its lowest point to a side-way Liner stub, of larger diameter, always cemented and sealed into the large Casing of the vertical Multi-lateral well, and containing the hanger-packer, sealing the upper end of said curved liner string, into said Liner

stub,

wherein said Liner string contains, in in its quasi-horizontal portion, a centralized single tubing string, hung, at its proximate end and via a thermal expansion joint, into the bottom part of said curved Liner string, and terminated by a First Polished Bore Receptacle, above a cup packer, used as back-flow preventer, and a First landing nipple and its matching retrievable plug,

wherein, the First Modular element of said Apparatus includes two parallel curved tubing strings, coupled together, at their lower ends, to the upper branches of an H, or Y, connector, whereas a lower branch of said First H, or Y, connector, leading to a first tubular Stinger, equipped with seals, and inserted in said First Polished Bore Receptacle, and the other lower branch of said H connector is plugged off,

wherein, one of said two parallel curved tubings is dedicated to supplying a lighter Oil-Lifting fluid to Oil-lifting devices respectively delivering said Oil-Lifting fluid to the other curved tubing string, used as Production tubing, and to the annular space between said curved Liner and said curved tubings,

wherein, the upper end of said curved Production tubing is equipped with a Second Polished Bore Receptacle,

wherein, the upper end of said curved Oil-Lifting fluid supply tubing is equipped with a Third Polished Bore Receptacle.

5. The Apparatus of Claim 4, wherein a Second Modular Assembly element, comprising parts two and three of said Apparatus, and

connected to the First Modular Assembly element of said Apparatus, includes, in its Part Two:

- a Production tubing, equipped, at its bottom end, with a Second sealing stinger, matching the Second Polished Bore receptacle,

- an Oil-Lifting fluid supply tubing, equipped, at its bottom end, with a Third sealing Stinger, matching the Third Polished Bore Receptacle, and connected to a third part of said Second Modular Assembly element of the Apparatus for said Lateral well;

and said Apparatus includes, in its Part Three, from the bottom up,

- means for establishing the following branch flow connections:

first, from the casing annular space to a coaxial, un-insulated, Production collector pipe, when said casing annular space is mostly filled with liquids (Oil and Water),

second, from said Production tubing to a central, insulated Steam tubing, during the Steam injection period, in said Lateral well,

third, from said Production tubing to said central Production Collector pipe, during the Lateral well's production period,

fourth, from said Production tubing to an Oil-lifting fluid supply tubing, parallel to the Production tubing, and located in a different radial plane than said Production tubing,

fifth, from said Oil-lifting fluid supply tubing to a vertical string of Oil-lifting fluid feeder tubings, rising through the multi-tubular packer at the top of said casing annular space's portion, dedicated to said Second and Third elements of said Lateral well's Apparatus, and crossing those portions of the casing annular space, stacked above that of said Lateral well, and dedicated to other Lateral wells;

- means for remotely operating said Natural Steam-lift and

Artificial Oil-lift systems in the Sequential Steam injection, Steam soak and Oil Production modes, using various combinations of said branch flow connections,

- means for, automatically, closing said first branch flow connection, when said annular space is filled with lower density fluids, such as Steam or Oil-Lifting fluid.

6. The Apparatus of Claim 5, wherein said means for remotely operating said Steam-lift and Oil-lifting systems in the Sequential Steam injection, Steam soak and Oil Production modes, using said branch flow connections include, from the top down:

- a retrievable plug, located in a Second landing nipple, in the Production tubing, closing said Fifth branch flow connection, except when logging or cleaning tools are to be introduced into said Lateral well's Production tubing,

- a surface-operated conventional "on-off" valve opening or closing said Fourth branch flow connection of said Oil-Lifting fluid supply tubing with said Oil-Lifting fluid feeder tubing string,

- a surface-operated 3-way valve, vertically located in the Production tubing, below said Second landing nipple and plug, either directing a Production fluids stream upwards into said Third branch flow connection to the Production Collector pipe, or directing Steam downwards from said Insulated Steam tubing, via said Second branch flow connection, into the Lateral well's Production tubing;

and wherein said means for, automatically, closing said First branch flow connection, from said casing annulus portion to said Production Collector pipe, include:

- a float valve, or a standing valve, set in a gas-lift valve mandrel within said Oil-lifting fluid supply tubing, which valve automatically directs, by an Artificial Oil-lifting process, a Production fluids stream from the casing annulus portion, via said First branch flow connection, to the Production Collector pipe, when the high density Produced liquids level is high within said casing annulus portion, and said float valve or standing valve also closes said First branch flow connection, when said Produced liquids level is low, due to the accumulation of Steam, of gas, or of Oil-lifting fluid within said casing annulus portion, during the Steam injection period and by a natural Steam-lift, during the Steam soak period.

7. A dedicated "Super-insulated" tubular assembly, for conveying wet Steam, with minimum heat losses, from a Generatr at the surface, to one or more of a plurality of Lateral wells, connected to a single large cemented Oil well casing pipe, hung from a single well head,

wherein,

said tubular assembly includes, radially, from the axis of said casing pipe:

- a pressure-resistant, leak-proof, metallic central tubing string, made-up of joints coupled together, end to end, by threaded couplings, and hung in the well head,
- a coaxial annular layer of porous "Super-insulating" fibrous or granular materials, of very low density, presenting a very fine pore space at near atmospheric pressure,
- a coaxial sealed insulation cover and support tubing string, also hung in the well head, made-up of thin-gauge metal joints, welded or

brazed together, surrounding said annular layer of "Super-insulating" material and said thin-gauge metal joints presenting a flexible annular support welded respectively to the outer surface of said central tubing and to the inner surface of said insulation cover tubing, at the respective two ends of each joint of said tubings,

- a plurality of wire-type metal centralizers, affixed to each joint of said central tubing, within its associated thin-gauge metal joint and each said centralizer presenting a radial extension, sliding into a rail guide affixed to the inner surface of said thin-gauge metal tube, parallel to its axis,
- a coaxial pressure-resistant protective metallic tubing string, made up of tight joints, coupled by metal to metal threads at each of their two ends, also hung in the well head and presenting an inner diameter slightly greater than that the outer diameter of said sheet metal tubing string,
- two coaxial stinger tubes, equipped with heat-resistant seals, for insertion of each of them into a matching Polished Bore Receptacle, respectively at the lower ends of said central metallic tubing string and of said coaxial outer protective metallic tubing string.

8. Metal wire centralizers, radial extensions, longitudinal guides, thin-gauge metal tubulars and flexible annular supports of Claim 7, making, together with either the outer surface or the inner surface of an adjacent steel tubular, the sealed annular enclosure of said "Super-insulating" materials, wherein,

said metals are selected alloys including two or more metals from the following alphabetic list:

Aluminum, Antimony, Cadmium, Copper, Chrome, Iron, Manganese,

Molybdenum, Nickel, Silicon, Silver, Titanium, Vanadium and Zinc, for their cost and respective compatibilities, and for their main relevant properties, within the temperature range of 100 C to 300 C, listed below:

- ease of assembly by welding or brazing,
- maximum elongation, by cold working in dies,
- high structural strength, ductility, and fatigue resistance,
- low thermal conductivity and thermal expansion, relative to those of the steel or of plating metals of said steel tubular and said thin-gauge metal tubular.

9. A modified version of the "Super-insulated" Steam tubular assembly joints of Claim 7, also pre-fabricated,

wherein,

said outer protective tubing joint, is used as the main structural support of the Super-insulation and of said insulation cover tube, made of thin-gauge metal, and as a substitute to the inner Steam tubing, wherein,

a jointless coiled tubing string, later inserted by conventional means, within said insulation cover tube, replaces the jointed Steam tubing string,

and wherein,

- said wire-type centralizers are now affixed on the inner surface of said Protective tubing joint, with their radial extensions pointing inward,
- said extensions are now sliding in rail guides affixed to the outer surface of the thin-gauge metal cover tube, of diameter only slightly larger than that of said coiled tubing,

- said flexible annular end supports of the thin-gauge metal cover tube are now affixed respectively on the inner surface of the protective tubular, and on the outer surface of said thin-gauge metal cover tube, thereby sealing the insulation inside a thin-gauge metal annular enclosure, fully protected from external shocks, by the thick outer protective pipe,
- the annular space between said coiled tubing outside diameter and the drift diameter of said thin-gauge metal insulation cover tubes, is very small,
- a low-pressure slip-stream of dry Oil-Lifting fluid, fills said annular space, carrying away and preventing any potential moisture leak, from contacting said insulation.

10. The coiled tubing, used as the Steam tubing string in Claim 9, is preferably made of a seamless tube of Titanium alloy,

wherein,

said coiled tubing is equipped at its lower end with a sealing stinger matching an associated Polished Bore Receptacle above the packer of the uppermost Apparatus, leading to the central insulated Steam tubing, previously hung within the stack of all the Lateral wells'Apparatus.

11. The "Super-insulated" coaxial production tubular string of Claim 2, conveying heated Oil to the surface, together with Steam condensate and Oil-Lifting fluid, including all the elements of the Steam tubular assembly of Claims 7 or 9, built on a much larger radial scale, so that the annular space between the inside diameter of the production tubing, in said production coaxial tubular assembly, exceeds, by two

inches or more, the outside diameter of the Steam tubular assembly's protective tubing string, which hangs, coaxially, within said production tubing string,

wherein,

in view of the heavy weight of the production tubing joints, the preferred configuration of said coaxial production tubular string of pre-fabricated joints is that of Claim 9,

wherein,

"slick" production tubing joints, of outside diameter slightly smaller than the drift diameter of the "Super-insulation" thin-gauge metal cover tubes, are separately shipped to the well site, coupled together on the rig and the resulting production tubing string is run into said pre-installed and, graphite-lubricated, insulation cover tubes, firmly supported within their outer protective tubular string, by wire centralizers and their radial extensions sliding in longitudinal guides, by flexible end collars and by seam welds at the junction of each thin-gauge metal joint,

wherein,

a slip stream of scavenging dry Oil-lifting fluid of low density, circulates in the very thin annular space between the outer surface of said protective tubular string and the inner surface of said insulation cover string, to dilute and carry away to the surface any accidental entry of moisture into said very thin annular space, to prevent said moisture from potentially breaking through the thin-gauge metal of the sealed insulation cover string, and

wherein,

the lower end of the outer protective tubular string of the production tubular assembly is closed by a welded ring, equipped on

the inside with circular seals, through which slides the production tubing string, above its lower-end stinger, sealed within a matching Polished Bore Receptacle, affixed to the top end of the un-insulated production collector pipe, affixed to the uppermost multi-tubular packer of all the stacked Apparatus, set within the vertical well casing.

12. Auxiliary Surface tools for protecting sealed "Super-insulation" thin-gauge metal cover tube joints from external shocks, during their transport, from the factory in which they are pre-fabricated, to a well site, and during their subsequent handling, and assembly into one or two strings, by a conventional service rig, at the well site, including:

- load-bearing, reinforced, thread protectors for single pin ends of said joints, wherein,

said "single pin" thread protectors present a box of threads, matching those of said joints pin, and a central, coaxial plug fitting within the lower end of said "Super-insulation" cover tube joints, presenting a strength sufficient for holding the combined weights of said "Super-insulation", of its said cover tube, of its internals and of its end collars, both vertically and horizontally, under predicted accelerations, and with reasonable safety factors, during transport of said joints to the well site and during their handling by the rig,

- load-bearing thread protectors for single box ends of said joints, wherein,

said "single box" thread protectors present a threaded pin matching those in said joint's box, and a coaxial plug fitting within

said insulation cover tube, presenting a strength sufficient for said joint to be handled by spiders and elevators in said rig; said single box or single pin thread protectors are used when the inside tubing joint of the "Super-insulated" tubular assembly is independently transported to said well site, by trucks on rough roads, or by ship, and run-in within the pre-installed insulation cover tubing,

- load-bearing thread protectors for dual pins ends of said joints, used when the completely assembled "Super-insulated" tubular joint is transported from the factory to the well site, including both the Steam tubing joint and the outer protective joint, assembled together by means of said dual pins, at their lower ends, wherein,

said "dual pin" thread protectors present a dual box of threads, matching those of the outermost pin of the protective tubing and those of the central pin of the inner tubing joint, either for Steam or for the Production fluids, providing a strength sufficient for limited transport and handling, and when the expected accelerations are quite low, such as with helicopters,

- the companion load-bearing thread protectors for "dual box" ends of said joints, presenting a dual threaded pin and a plug inserted within the innermost tubing joint;

said auxiliary surface tools also include:

- modified "seam welding" machines for joining and sealing together the respective ends of the insulation cover thin-gauge metal tubes of two superposed joints held in the slips and in the top drive of the rig, prior to running-in of the coupled joint of the "Super-insulated" tubular assembly, for conveying either Production fluids or Steam,